DTU Library

Creating Materials with Negative Refraction Index using Topology Optimization

Christiansen, Rasmus Ellebæk; Sigmund, Ole

Publication date:
2016

Document Version
Peer reviewed version

Creating Materials with Negative Refraction Index using Topology Optimization

Authors:
Rasmus Ellebæk Christiansen[1], *Ole Sigmund.*
Department of Mechanical Engineering, Technical University of Denmark.

Abstract

We apply topology optimization along with full modeling of the electromagnetic (acoustic) field to create metamaterials with negative refraction index. We believe that our approach can be used in the design of metamaterials with specific effective permittivity and permeability e.g. by adapting the approach presented in [1].

We model the problem in 2D in the frequency domain using the Helmholtz equation and discretize the model using the hybrid WBM-FEM method [2]. We consider a modulated plane wave incident at an angle on a slab consisting of a periodic array of identical design cells whose size is on the order of the wavelength. We seek a distribution of solid and air in the design cell yielding a prescribed negative refraction index for the slab.

Our objective is to minimize the difference in amplitude between the solution to the model problem and a prescribed modulated plane wave behind the slab. The direction of propagation for the prescribed wave is chosen to match the angle of incidence of the incoming plane wave and its position is used to select the refraction index for the slab. We introducing a continuous design field and apply The Method of Moving Asymptotes to perform the optimization. A filter is used for regularization and a projection step applied to obtain clean 0/1 designs. A continuation scheme is used to avoid stagnation in the optimization.

Metamaterials with negative refraction index designed using this method are presented. The angular dependence of the refraction index and of the reflection and transmission coefficients are investigated.

References

[1] Castanié, A. ; Mercier, J.-F. ; Félix, S. & Maurel, A. *Generalized method for retrieving effective parameters of anisotropic metamaterials.* Optical Express, Vol 22, Issue 24, Pages 29937-29953, 2014.

[2] Bert, P. *Wave Based Modelling Methods for Steady-State Vibro-Acoustics.* Katholieke Universiteit Leuven, 2006.

[1]E-mail: raelch@mek.dtu.dk
Address: Nils Koppels Allé 404, DK-2800 Kgs. Lyngby, Denmark